WOODLAKE DAM TEMPORARY BREACH DESIGN – CONCEPT SUBMITTAL

Woodlake Dam Rehabilitation
Woodlake CC Corp.
Vass, NC

Schnabel Reference No: 17C21008.00
April 10, 2017

Schnabel ENGINEERING

SCHNABEL ENGINEERING SOUTH, P.C.

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Laura Shearin, PE, ENV SP
NC Professional Engineering No. 037496

Schnabel Engineering South, P.C.
License Number C-2599

April 10, 2017

Mr. Brian Shane Cook, PE, LSIT
State Dam Safety Engineer
NC DEQ - Land Quality Section
512 N. Salisbury Street, Room 519
1612 Mail Service
Raleigh, NC 27604

Subject: Project 17C21008.00, Woodlake Dam Temporary Breach Design – Concept Submittal, Vass, NC

Dear Mr. Cook:

SCHNABEL ENGINEERING SOUTH, P.C. (Schnabel) is pleased to submit our concept for the breach design at Woodlake Dam on the behalf of Woodlake CC Corp. (WCCC). This report includes tables, and appendices with relevant data collected for this design.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

SCHNABEL ENGINEERING SOUTH, P.C.

R. Indri

Robert Indri, PE
Associate

RTI:LS:MEL

Distribution:
Client (1 Copy),
Attn: Chris Meng and David Harris

NCDEQ: Dam Safety (2 Copies)
Attn: Shane Cook, PE; State Dam Safety Engineer

WOODLAKE DAM TEMPORARY BREACH DESIGN – CONCEPT SUBMITTAL
WOODLAKE DAM REHABILITATION
WOODLAKE CC CORP.
VASS, NC

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APPENDICES

1.0 DESCRIPTION OF SITE AND PROPOSED CONSTRUCTION

1.1 Site Description

Woodlake Dam is located in Moore County, North Carolina, approximately 2,450 feet northwest of the intersection of Lobelia Road (SR 690) and McGill Road (SR 2017). The dam is owned by Woodlake CC Corp (WCCC). The primary purpose of the impoundment is recreation. Water from the impoundment is also used for irrigation at the adjacent Woodlake golf course. The dam impounds Lake Surf and has a maximum impoundment capacity of approximately 10,000 acre-feet at the top of the dam. Woodlake Dam is considered a large sized, high hazard dam by NCDEQ Dam Safety. A Site Vicinity Map is included in Appendix A.

Woodlake Dam consists of: an approximately 23 foot-high earth embankment; a reinforced concrete chute principal spillway with approximately 3.5-foot-high metal slide gates across the control section of the chute; and, two low-level outlets as independent structures.

1.2 Project History

In early October (starting on October 9, 2016), high water flows through the principal spillway from Hurricane Matthew caused portions of the concrete spillway to undermine, collapse, and displace. Emergency measures were taken, including opening of the two low-level outlets gates, and installation of large pumps to decrease the water levels in the reservoir. The principal gates were closed in an attempt to reduce flows through the principal spillway and reduce the potential for continued displacement of the spillway slabs and erosion of the spillway subgrade. The Emergency Action Plan (EAP) for the project was implemented and downstream residences in the breach inundation zone were notified and evacuated.

During an on-site inspection on October 12, 2016, NCDEQ Dam Safety noted the following deficiencies at the dam:

- The middle section of the concrete spillway on the downstream side had collapsed;
- Erosion under the collapsed spillway section had occurred;
- The seepage drainage system had been damaged;
- The downstream spillway walls had been overtopped and soil erosion had occurred from behind the walls; and,
- Most of the gates were not completely functional and were damaged.

Under a March 15, 2017 court order, the owner has been ordered to:

- Maintain the water level in the impoundment at an elevation of EL 211 or below; and,
- Finish design and construction of a temporary full breach of the dam within 105 days of issuance of the court order.

1.3 Status of Temporary Full Breach Design Submittal

This report and attached drawings represents our concept submittal for temporary full breach of Woodlake Dam. The final breach design will be developed for submission to Dam Safety for review and approval pending completion of a topographic survey of the site. The concept is based on 2005 LiDAR obtained from NC Floodplain Mapping. We do not consider the LIDAR topographic data and historical drawings used to develop the concept submittal sufficient for final design of the breach. Our surveying sub consultant, Allied Associates, PA (Allied), mobilized to the site on April 5, 2017 to begin the site survey.

To meet project deadlines, the client has elected to pursue a design-build contract for completion of the breach. Crowder Construction (Crowder) has been selected as the general contractor and WCCC is currently in the preliminary stages of negotiating a contract with Crowder. Crowder will work with Schnabel during the design phase by providing constructability reviews and cost estimating. Modifications to the concept submittal based on Crowder's input will be included in the final design submittal.

The intent and concepts presented are not expected to significantly change as we prepare the final design. If significant modifications are required based on the results of the survey and constructability review, we will contact Dam Safety to review the modifications.

1.4 Proposed Temporary Full Breach

The proposed temporary full breach will include removal of the existing principal spillway in its entirety. A two-stage armored channel will be constructed centered on the existing principal spillway. The details of the channel are outlined in the next section of this report and shown on the figures included in Appendix A. Construction access will be from McGill Road to the left abutment of the dam. A spoils disposal area has been identified by the Owner and is shown in the figures included in Appendix A.

2.0 HYDRAULICS AND HYDROLOGY

2.1 Standard Design Flood

Woodlake Dam is considered a large sized, high hazard dam. The standard design flood (SDF) for this structure is the ¾ Probable Maximum Precipitation (PMP). Our understanding is NC Dam Safety requires the temporary full breach design to be sized to pass the ¾ PMP, including full armoring within the breach section of the embankment up to the water surface elevation of the ¾ PMP.

2.2 Watershed Hydrology

The 95 square mile watershed was modeled as a single basin. An SCS runoff curve number of 68 was calculated using the National Land Cover Dataset cover and USDA Soils data for Harnett, Lee, and Moore Counties. A Snyder's Lag Time of 9.9 hours was calculated using an average watershed slope of 6.22% and a stream length of 16.56 miles. A peaking coefficient of 0.4 was selected based on other regional basin analyses. The watershed and reservoir were modeled using HEC-HMS 4.2.

The rainfall for the PMP was obtained from HMR 51 and distributed in the HEC-HMS model. The rainfall for the 100-year and 500-year storms was obtained from NOAA Atlas 14. All storms were modeled with a 24-hour duration.

2.3 Reservoir and Temporary Full Breach Routing

The temporary full breach will have a control section elevation of 209 feet. The reservoir storage was calculated using NCFMP topography supplemented by historical data when necessary. The top of dam will remain at elevation 230.5 feet.

The proposed temporary breach will be a two staged channel. The lower stage will be 130 feet wide with 3H:1V side slopes. The second stage will be 100 feet wide on either side of the lower state at elevation 220 with 3H:1V side slopes. The lower stage contains the 500-year storm.

Tailwater at the temporary breach was calculated using HEC-RAS 4.1. The downstream model was developed using NCFMP topography and bridge information from the FEMA FIS for Moore County. The results of the temporary breach model from the 100-year, 500-year, and ¾ PMP are included below.

Table 1: Headwater/Tailwater

Storm Event	Rainfall Depth, 24-hour (inches)	Storm Outflow (cfs)	Headwater (ft)	Tailwater (ft)
100-year	8.19	7,657	215.4	211.8
500-year	10.3	10,947	216.7	213.4
¾ PMP	21.87	35,798	223.2	218.6

2.4 Temporary Full Breach Lining

The temporary full breach will be lined with 12-inch Reno Mattresses. Due to the high tailwater at the site, the 100-year storm was analyzed to size the breach lining. A maximum velocity of 20.5 ft/s was calculated for the 100-year storm, assuming no tailwater. The actual velocity is expected to be less than this due to the impacts of tailwater. The 12-inch Reno Mattress has a permissible maximum velocity of 21 ft/s. The manufacture specifications are included in Appendix B. The Reno Mattresses will terminate at the edge of the endsill sheetpile wall. The concrete cap of the sheetpile wall will be removed and the sheetpiles will be cut as appropriate to match the downstream edge of the Reno Mattresses.

3.0 REFERENCES

<u>Drawings:</u>

Remedial Dam Repair Plans, Woodlake Dam, Moore County, North Carolina; S&ME; July, 1988.

Construction Plans and Specifications, Phase I Dam Remediation, Spillway Structure Slabs & Walls; Marks Enterprises of NC, PLLC; January, 2011.

Construction Plans and Specifications, Phase I Dam Remediation, Spillway Structure Slabs & Walls; Marks Enterprises of NC, PLLC; August, 2014.

Reports:

Dam Remediation Design Submittal, Woodlake Dam Phase I Spillway Remediation; Marks Enterprises of NC, PLLC; January 17, 2011.

Review Comments Responses Documents, Dam Remediation Design Submittal, Woodlake Dam Phase I Spillway Remediation; Marks Enterprises of NC, PLLC; September 1, 2014.

APPENDIX A

DRAWINGS

WOODLAKE DAM TEMPORARY FULL BREACH

PREPARED FOR

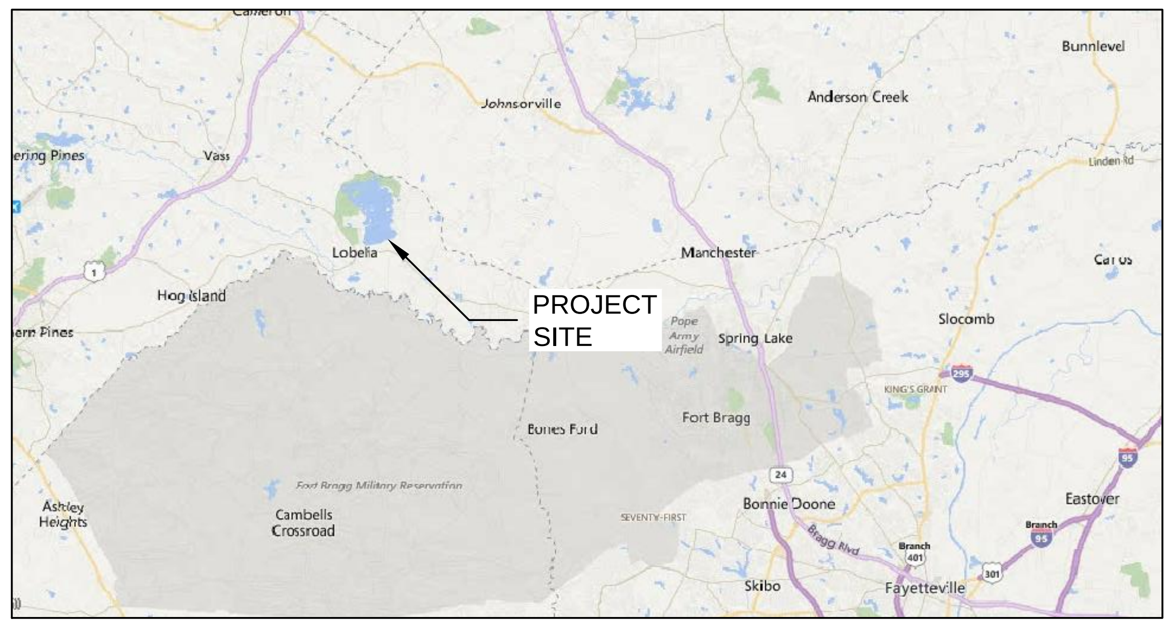
WOODLAKE CC CORP

VASS, NORTH CAROLINA

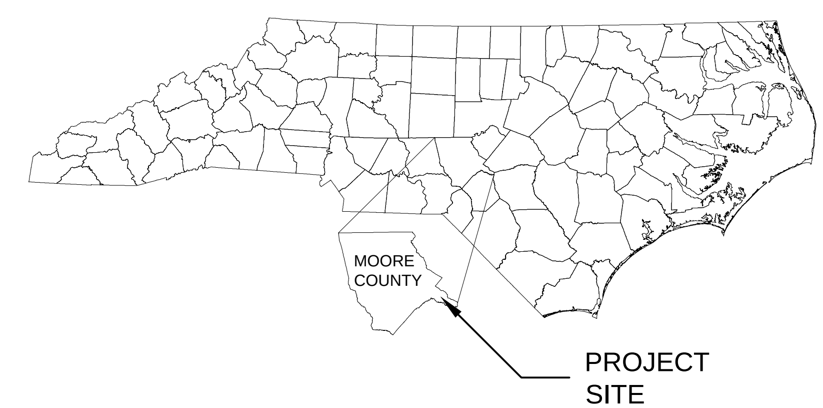
PREPARED BY

SCHNABEL ENGINEERING SOUTH, PC

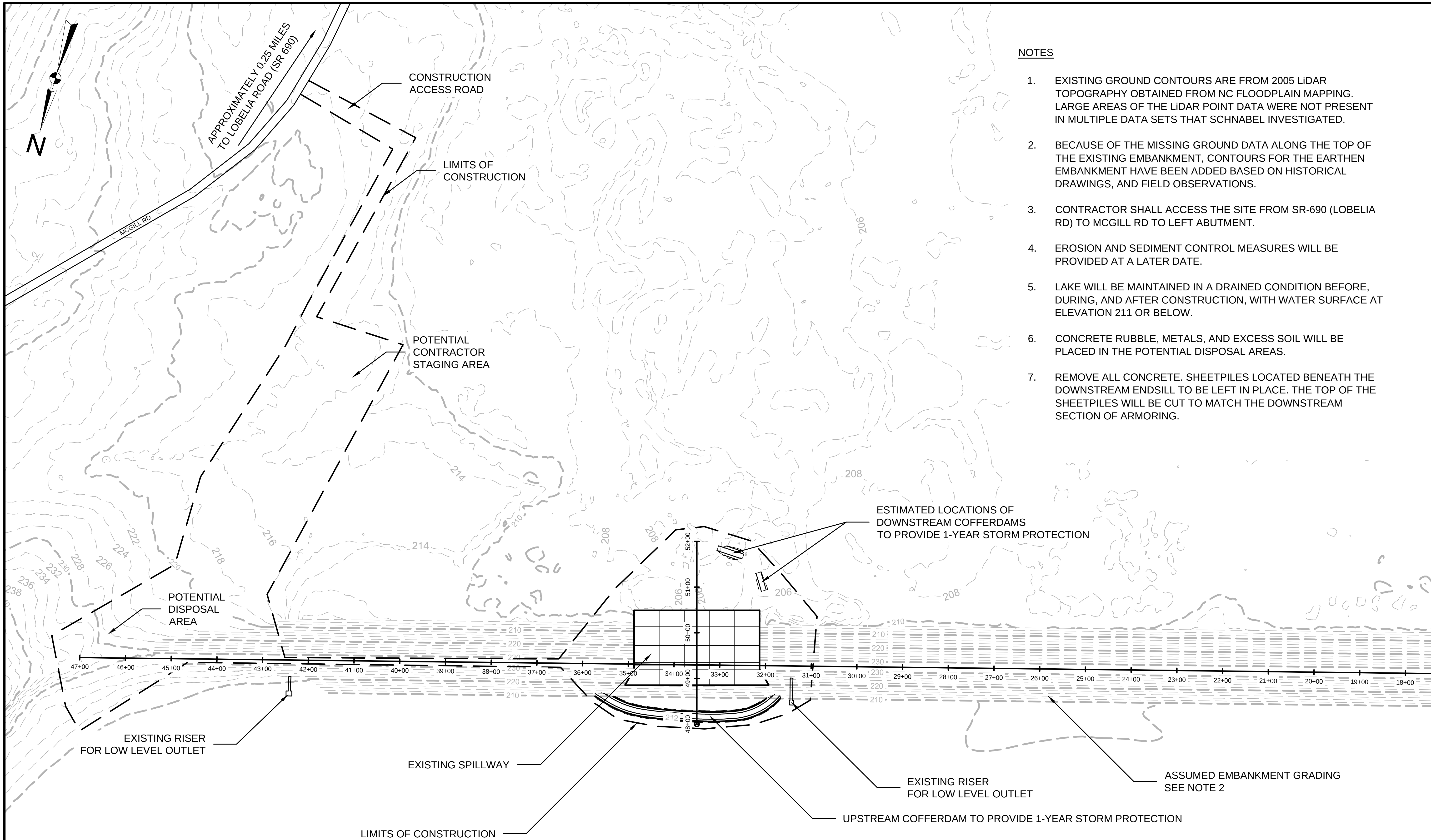
VICINITY MAP



LOCATION MAP



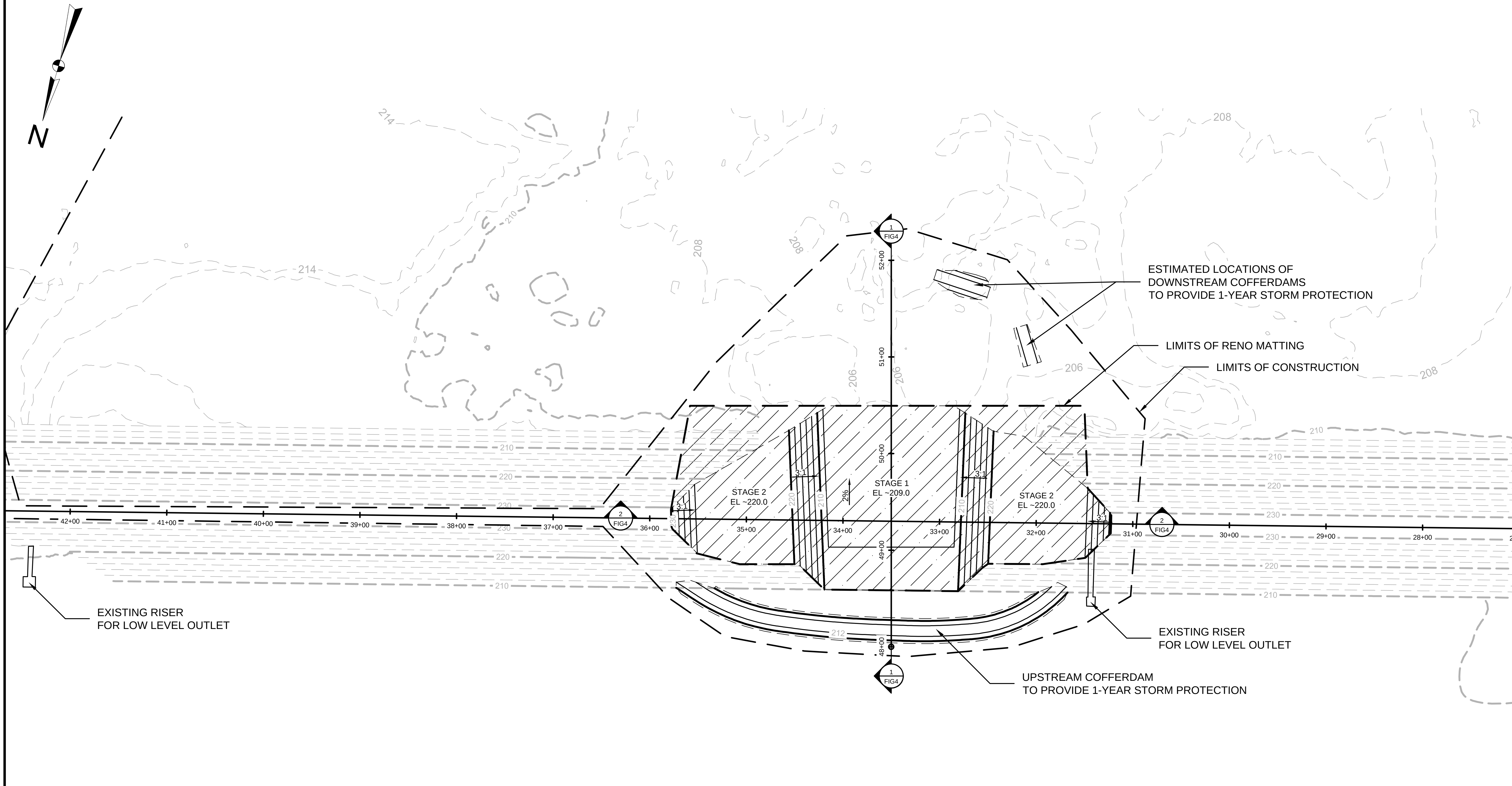
Schnabel ENGINEERING	WOODLAKE DAM TEMPORARY FULL BREACH WOODLAKE CC CORP VASS, NORTH CAROLINA	COVER SHEET FIGURE 1



NOTES

1. EXISTING GROUND CONTOURS ARE FROM 2005 LiDAR TOPOGRAPHY OBTAINED FROM NC FLOODPLAIN MAPPING. LARGE AREAS OF THE LiDAR POINT DATA WERE NOT PRESENT IN MULTIPLE DATA SETS THAT SCHNABEL INVESTIGATED.
2. BECAUSE OF THE MISSING GROUND DATA ALONG THE TOP OF THE EXISTING EMBANKMENT, CONTOURS FOR THE EARTHEN EMBANKMENT HAVE BEEN ADDED BASED ON HISTORICAL DRAWINGS, AND FIELD OBSERVATIONS.
3. CONTRACTOR SHALL ACCESS THE SITE FROM SR-690 (LOBELIA RD) TO MCGILL RD TO LEFT ABUTMENT.
4. EROSION AND SEDIMENT CONTROL MEASURES WILL BE PROVIDED AT A LATER DATE.
5. LAKE WILL BE MAINTAINED IN A DRAINED CONDITION BEFORE, DURING, AND AFTER CONSTRUCTION, WITH WATER SURFACE AT ELEVATION 211 OR BELOW.
6. CONCRETE RUBBLE, METALS, AND EXCESS SOIL WILL BE PLACED IN THE POTENTIAL DISPOSAL AREAS.
7. REMOVE ALL CONCRETE. SHEETPILES LOCATED BENEATH THE DOWNSTREAM ENDSILL TO BE LEFT IN PLACE. THE TOP OF THE SHEETPILES WILL BE CUT TO MATCH THE DOWNSTREAM SECTION OF ARMORING.

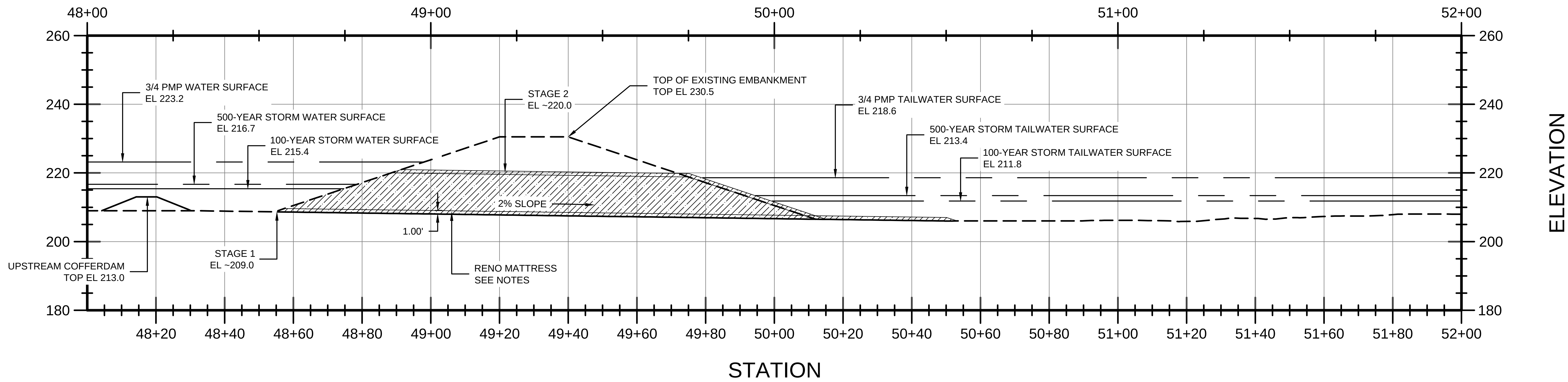
Schnabel ENGINEERING	WOODLAKE DAM TEMPORARY FULL BREACH WOODLAKE CC CORP VASS, NORTH CAROLINA	SITE ACCESS AND CONSTRUCTION LIMITS FIGURE 2



NOTES

1. EXCAVATE TO MATCH GRADES AS SHOWN. PROVIDE SMOOTH AND LEVEL PLATFORM FOR FABRIC AND RENO MATTRESS PLACEMENT.
2. RENO MATTRESS SHALL BE PVC COATED MACCAFERRI (OR APPROVED EQUIVALENT) 12-INCH RENO MATTRESS, STONE SIZE 3.9 TO 5.9-INCH DIAMETER WITH D50 = 4.9 INCHES. PROVIDE MIRAFTI 180N UNDERNEATH MATTRESSES.

Schnabel ENGINEERING	WOODLAKE DAM TEMPORARY FULL BREACH WOODLAKE CC CORP VASS, NORTH CAROLINA	TEMPORARY FULL BREACH PLAN FIGURE 3

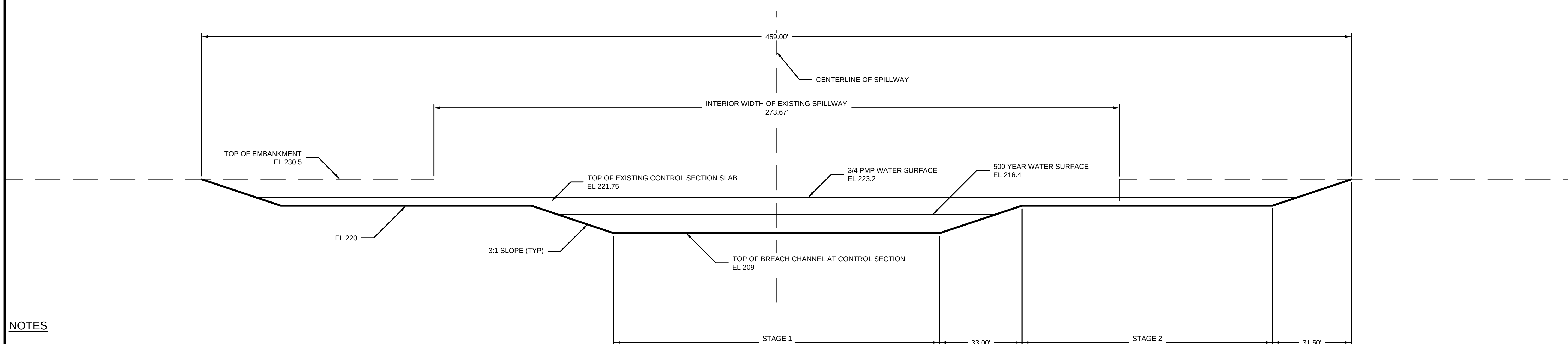


1
FIG3

TEMPORARY FULL BREACH PROFILE

SCALE: 1"=30'

0 30' 60'



NOTES

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2
FIG3

SECTION AT CENTERLINE OF EXISTING EMBANKMENT

SCALE: 1"=40'

0 40' 80'

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WOODLAKE DAM TEMPORARY
FULL BREACH
WOODLAKE CC CORP
VASS, NORTH CAROLINA

TEMPORARY FULL BREACH
PROFILE AND SECTION

FIGURE 4

APPENDIX B

HYDRAULIC AND HYDROLOGIC CALCULATIONS

Project: Woodlake Dam   Simulation Run: 0.75 PMP- PostBr
Reservoir: Woodlake Dam

Start of Run:	01Jan2017, 00:00	Basin Model:	Temporary Breach
End of Run:	07Jan2017, 00:00	Meteorologic Model:	Woodlake PMP-24hr
Compute Time:	08Apr2017, 08:43:20	Control Specifications:	6 days, 5 min incr

Volume Units: IN

Computed Results

Peak Inflow:	39255.9 (CFS)	Date/Time of Peak Inflow:	02Jan2017, 01:05
Peak Discharge:	35798.4 (CFS)	Date/Time of Peak Discharge	02Jan2017, 04:35
Inflow Volume:	17.09 (IN)	Peak Storage:	10816.6 (AC-FT)
Discharge Volume	17.08 (IN)	Peak Elevation:	223.17 (FT)

Project: Woodlake Dam   Simulation Run: 500-year - PostBr
Reservoir: Woodlake Dam

Start of Run:	01Jan2017, 00:00	Basin Model:	Temporary Breach
End of Run:	07Jan2017, 00:00	Meteorologic Model:	500-year-24hr
Compute Time:	08Apr2017, 08:42:19	Control Specifications:	6 days, 5 min incr

Volume Units: IN

Computed Results

Peak Inflow:	12312.0 (CFS)	Date/Time of Peak Inflow:	01Jan2017, 22:55
Peak Discharge:	10946.6 (CFS)	Date/Time of Peak Discharge	02Jan2017, 04:15
Inflow Volume:	5.61 (IN)	Peak Storage:	4497.2 (AC-FT)
Discharge Volume	5.60 (IN)	Peak Elevation:	216.73 (FT)

Project: Woodlake Dam Simulation Run: 100-year - PostBr
Reservoir: Woodlake Dam

Start of Run:	01Jan2017, 00:00	Basin Model:	Temporary Breach
End of Run:	07Jan2017, 00:00	Meteorologic Model:	100-year-24hr
Compute Time:	08Apr2017, 08:41:38	Control Specifications:	6 days, 5 min incr

Volume Units: IN

Computed Results

Peak Inflow:	8517.3 (CFS)	Date/Time of Peak Inflow:	01Jan2017, 23:10
Peak Discharge:	7657.1 (CFS)	Date/Time of Peak Discharge:	02Jan2017, 04:25
Inflow Volume:	3.93 (IN)	Peak Storage:	3361.3 (AC-FT)
Discharge Volume:	3.92 (IN)	Peak Elevation:	215.35 (FT)

Trapezoidal Channel Normal Depth Calculations

Inputs

Flow Rate (cfs)	7657
Bottom Width (ft)	130
Side Slope (ft/ft)	3
Channel Slope (ft/ft)	0.042
Manning's n	0.0277

Calculate

Results

Normal Depth (ft)	2.71
Area (ft^2)	373.95
Wetted Perimeter (ft)	147.12
Channel Velocity (ft/s)	20.48

MACCAFERRI

ALLOWABLE WATER VELOCITIES

Type	Thickness	Filling stones (in)		Critical Velocity	Limit Velocity
	(in)	Stone Size	d_{50}	(fps)	(fps)
Reno mattress	6	2.8 - 3.9	3.4	11.5	13.8
Reno mattress	6	2.8 - 5.0	4.3	13.8	14.8
Reno mattress	9	2.8 - 3.9	3.4	11.8	18.0
Reno mattress	9	2.8 - 5.9	4.7	14.8	20.0
Reno mattress	12	2.8 - 4.7	3.9	13.8	18.0
Reno mattress	12	3.9 - 5.9	4.9	16.4	21.0
Gabions	18	3.9 - 8.0	5.9	19.0	25.0
Gabions	18	4.7 - 9.8	7.5	21.0	26.2

MACCAFERRI

ALLOWABLE SHEAR STRESSES

Type	Stone size (inch)	Average diameter d_{50} (inch)	END OF INSTALLATION		VEGETATION COMPLETELY GROWN	
			Roughness n (Manning)	Allowable tractive force τ_l (psf)	Roughness n (Manning)	Allowable tractive force τ_l (psf)
Gabions (18 inch)	4.0 - 10	7.50	0.0301	7.14	0.07 - 0.4 (d)	8.35
Reno Mattress (6 inch)	2.8 - 5.0	3.90	0.0277	4.26	0.07 - 0.4 (d)	8.35
Reno Mattress (9 inch)	2.8 - 5.9	4.70	0.0277	4.88	0.07 - 0.4 (d)	8.35
Reno Mattress (12 inch)	2.8 - 8.0	5.40	0.0277	5.64	0.07 - 0.4 (d)	8.35
Mastic grouted R.M. (9 inch)	2.8 - 5.9	4.70	0.0158	6.77	0.07 - 0.4 (d)	8.35
Macmat-R (TRM)			0.0303	0.74 - 3.34 (a)	0.07 - 0.4 (d)	6.26

(a): It is a function of the flood duration

(b): The coefficient shall be computed on the basis of the real typology of the work, taking into account shape and dimensions of the stones using equation (12)

(c): The actual resistant shear depends on the stone dimensions and may be computed using the equation (24)

(d): It Depends on the vegetation growth

(e): The actual resistant shear stress depends on the stone dimensions and may be computed using the equation